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REVIEW ARTICLE

Measurement of Human Blood pressure – a guideline for General Practitioners

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Abstract:

Blood pressure is a vital parameter. Stephen Hales first measured BP and Scipione Riva-Rocci developed the prototype of the present day sphygmomanometer. Both directly and indirectly BP can be measured. The indirect method Includes sphygmomanometric method,ultrasound doppler method, oscillometric method, self measurement and ambulatory BP monitoring. For proper measurement of BP by auscultatory method, one should have adequate knowledge of equipment and cuff size, proper technique and Korotkoff sounds. In different situations like arrhythmias, shock, hyperkinetic circulatory states and aortic regurgitation, BP should be measured carefully. In recent years home BP monitoring and ambulatory BP monitoring are becoming popular. Care must be taken to avoid both underestimation and overestimation of BP recording.

Introduction

Blood pressure is a vital parameter. It is carried out by the doctors & physicians of every discipline and mostly practiced clinical examination. It is our responsibility to measure BP accurately & scientifically.

History

Stephen Hales, an English clergyman, first measured BP by sacrificing his horse in 1733.[1] Karl Vierdot (1818-1884) introduced the first sphygmographic method for indirect measurement of BP. Samuel Siegfried Von Basch (in 1881) developed the first non-invasive sphygmomanometer.[2] Scipione Riva-Rocci in 1896 developed the prototype of the present day instrument.[3] In 1905, Nikolai S Korotkoff discovered the arterial sounds, which are known as "Korotkoff sound".[4] With the extensive description of these sounds as Ki & Kc by McCutcheon and Rushmer in1967, the auscultatory method became the most common and popular non-invasive method of measurement of blood pressure.[5]

Methods

Measurement of human blood pressure can be divided into two methods-

Direct Methods

At present, for the direct and continuous measurement of arterial pressure electromanometer is used, which is a transducer that converts mechanical energy into an electrical signal suitable for amplification, display and recording. In this method, the artery is cannulated with a saline filled catheter or needle that mechanically couples the circulation to the arterial manometer. The use of side-hole catheter (instead of end hole catheter) positioned in a large, patent artery allows the measurement of true arterial pressure with less measurement errors.[6] Self-flushing strain gauge manometers which are directly attached to an intravascular catheter or needle, eliminate many of the problems related to transducer mounting, flushing and over damping by connecting tubes. The uses of intravascular electromanometers mounted on cardiac catheters are the best method of direct measurement of arterial pressure.

Indirect Methods

The various indirect methods are-

- Sphygmomanometric measurement
  - i. Palpatory
  - ii. Auscultatory
  - iii. Flush methods
- Ultrasound Doppler method
- Oscillometric method
- Self measurement (Home BP recordings)
- Ambulatory BP monitoring.

i. Palpatory Method

Without sphygmomanometer-

Systolic blood pressure can be estimated approximately by compressing the brachial artery to obliterate ipsilateral radial pulse. If relatively mild compression of brachial artery obliterates the ipsilateral radial pulse, the SBP is <120mmHg and if considerable compression is required to obliterate radial pulse, the SBP may be >160mmHg.[7]

With sphygmomanometer-

In this method, the standard cuff of a sphygmomanometer is applied to the upper arm with the lower edge 2.5cm above

the antecubital fossa and cuff is inflated 30mmHg above the anticipated SBP, which obliterates the brachial pulse. Then the cuff is deflated slowly and approximate peak systolic pressure is the point at which the brachial pulse first reappears consistently. After further deflation, the diastolic pressure can be estimated with the distinct snapping quality of the palpable pulse.[7]

ii. Auscultatory method

For proper measurement of BP with this method, we have to know about the adequate equipment & cuff size, proper technique and korotkoff sounds & phases.

Adequate equipment & cuff size

The equipments required for auscultatory method of BP measurement are a sphygmomanometer and a stethoscope. Again, sphygmomanometer consists of bag & cuff and a manometer.

The unyielding covering surrounding the inflatable bag is called "the Cuff". The width of a standard cuff should be 20% more than the limb diameter or 40% of the limb circumference. The length of the cuff should be adequate to encircle at least 80% of the limb.[8] The ratio between width and length should be 1:2. The standard cuff size is 5" (12-16cm) wide with a length of 10" (22-36cm).[9] The cuff size is determined by the size of the limb, not by the age of the patient. The width of the cuff should be 1.5" in infants & small children, 3" in young children (2-5 yrs of age) and 8" in obese adults. There are six sizes of commonly available BP cuffs: newborn, infant, child, normal adult, large adult & thigh.[10] A common source of error in clinical practice is the use of inappropriately small or large cuff. When a cuff is applied to a large arm in an obese or to a normal thigh, arterial systolic pressure would be overestimated and when it is applied to a small arm, the SBP would be underestimated.[9] The cuff mismatch may be corrected to some extent by the following formula. If a cuff is relatively smaller:

32 - (1.05 x arm circumference in cm).

If the result +ve, add it to the recorded BP and if found –ve, subtract from the recorded BP.[11]

The manometers are of two types, mercury manometer and aneroid manometer. In mercury manometers, there should be no loss of mercury. Resting level of mercury meniscus should be exactly at zero mark. The column of manometer must be vertical. Clogging in the air vent at the top of the manometer tube will cause the mercury to respond poorly to pressure and may give erroneous result. However, mercury manometers are being replaced by new equipments due to environmental contamination (by mercury spillage). The aneroid manometer should be calibrated yearly or more often with a perfectly functioning mercury manometer.

The stethoscope should be of a standard variety with a good earpiece & diaphragm.

Proper technique

A properly trained observer with proper mental concentration and audio-visual perfection should measure the BP. S/he should have clear idea about cuff size, measurement procedure and korotkoff sounds & phases. S/he should inflate or deflate the cuff properly. Incase of mercury manometer, the mercury meniscus should be at equal level of observer's eyes. S/he also should not be in a strained position while taking recordings of blood pressure.

The patient should avoid tea, coffee, smoking or exercise for 30 minutes before BP measurement. Because caffeine, tobacco & exercise elevate the BP, which may return to baseline in 15-30 minutes.

Anxiety, emotional lability, distended bladder or other abdominal viscera, pain, meal, climatic variation etc. also influence the BP recording. So, these biological factors should be avoided or controlled if possible and if not possible, should be mentioned with the recorded BP. For proper measurement, patient should be in a relaxed mood, comfortably seated for at least 5 min in a chair with feet on the floor (uncrossed), back supported and arm at the heart level in a quiet room with comfortable temperature. In the supine position, the arm should be raised to bring it to the level of the mid-Right Atrium (i.e. elevated on a pillow).[12] The arm should not be constricted with tight clothing or other materials. There should be no conversation between patient and observer during BP measurement.

The deflated cuff should be applied snugly over the artery, at the heart level with its lower border at least 1" (2.5cm) above the antecubital fossa, keeping the rubber bag over the inner aspect of the arm. The brachial artery is then palpated in the antecubital fossa. Fix the site, where the diaphragm of the stethoscope should be applied. Radial pulse is then palpated, inflate the cuff to a pressure of 20-30mmHg above the anticipated systolic pressure (peak inflation level) which is indicated by obliteration of radial pulse. The diaphragm of stethoscope is applied firmly over the brachial artery. Heavy pressure may give falsely low diastolic pressure. At the conclusion of BP measurement, there should be no lasting indentations, where the diaphragm of stethoscope was applied.[10] The stethoscope should not touch the clothing or cuff. The cuff is then slowly deflated at a rate of 20mmHg/beat or 2-3mmHg/sec. Rapid deflation may cause sounds to be missed and BP could be underestimated (in case of sinus bradycardia or irregular rhythm). Too slow deflation or re-inflation for repeat measurement may artificially elevate the diastolic BP and falsely decrease the systolic pressure due to resultant venous congestion. The cuff should be deflated rapidly and completely after the diastolic pressure is noted and a full minute is allowed to elapse before the pressure is re-measured in the same limb.

Korotkoff sounds & phases

Korotkoff sounds are divided into five phases [5]

- Phase I consists of clear tapping sounds which occur when the cuff pressure has reached the arterial peak systolic pressure.
- Phase II consists of soft murmurs, 5-10mmHg lower than the peak systolic pressure.

- Phase III consists of augmented phase II sounds & murmurs, 5-10mmHg below phase II.
- Phase IV is the sudden muffling of sounds, 5-10mmHg higher than phase V.
- Phase V is the complete disappearance of korotkoff sounds when the artery is no longer compressed to produce turbulent flow.

Phase I indicates systolic blood pressure and phase V defines diastolic blood pressure. There are some conditions where both phase IV & phase V should be recorded as diastolic blood pressure, e.g. in severe AR, hyperkinetic circulatory states like fever, hyperthyroidism, vigorous exercises etc. In such cases, muffling of sound should be noted as diastolic pressure. As the concerned authorities are still remaining undecided about the 'correct' level of recording, both of the last two phases should be used as DBP, e.g. 120/80/70mmHg (80-phase IV, 70-phase V).[9]

Auscultatory gap

It occurs in phase II when the sounds & murmurs are not heard due to venous distension or poor antegrade arterial flow. It is commonly found in older, hypertensive patients with target organ damage and may reflect intra-arterial fluctuations in pressure.[14] The gap can be as much as 40mmHg, thus one can underestimate the systolic blood pressure or overestimate diastolic blood pressure. This error can be avoided by palpating for disappearance of radial pulse during raising the cuff pressure. The gap can be eliminated by raising the arm for 30 seconds and clenching the fist several times before measuring BP.[9]

Measurement of BP in lower limbs

To measure BP in the thigh, the patient should lay on his/her abdomen. A thigh cuff (8″ wide, 18-20cm) is applied with compression over the posterior aspect of mid thigh. Auscultation is done over popliteal artery in popliteal fossa. When 8″ wide cuff is not available, an arm calf can be used. It is applied in the lower leg over the calf muscles & auscultation can be done either over posterior tibial artery or arteria dorsalis pedis. To increase the audibility of korotkoff sounds, exercise of limb can be helpful.

BP measurement in special circumstances

Severe AR & hyperkinetic circulatory states- Diastolic pressure should be recorded both at phases IV & V.

Arrhythmias- In case of irregularly irregular rhythm (e.g. Atrial fibrillation) stroke volume & BP varies from cycle to cycle, which may result in underestimation of BP. So, several recordings (at least three recordings) should be taken and average is noted in each limb.

Shock- Korotkoff sounds are not clearly audible or absent due to reduced cardiac output or increased peripheral resistance. So, direct method is used in such circumstances.

Infants and children- For newborn, infants and children, cuff of different sizes should be used according to limb size. Observer should keep in mind that crying can increase SBP by 30-50mmHg.[13] Again in newborn & infants (below 1yr); korotkoff sounds may be too faint to recognize. So, other indirect methods are recommended. Average SBP at 1 yr of age is 90mmHg and increases by 5mmHg every 3 years of age and reaches 120mmHg by 12-13years of age. But the DBP is usually 60 $\pm$ 10mmHg. For the expectant SBP of children, the following formula can be used[15]

$$SBP = 90 + (age \times 5) / 3.$$

Flush method of BP recording

This method is helpful in suspected Coarctation of aorta where auscultatory sounds or palpated pressures are not obtainable. For this method, BP cuff is applied to the limb (arm or thigh) properly, limb is elevated. An elastic bandage is applied from fingertips & toes proximally to eliminate the blood from the skin capillaries & veins. As a result distal forearm and hand (or leg and foot) become blanched. Then the cuff is inflated 20mmHg above the anticipated SBP and the elastic bandage is removed. The distal limb should be found pale & white. BP cuff is then deflated at a rate of 2mmHg/sec. The pressure at which first blush appears in the limb is recorded which is closer to the mean pressure, not the peak systolic pressure. The reading is 10-30mmHg lower than SBP obtained by auscultatory method.

Ultrasound Doppler method

In this method, the transducer is placed over an artery. The arterial wall oscillations are transformed into an audible signal (sounds) at the peak intravascular systolic pressure and sounds disappear when the intravascular pressure dips below the end diastolic pressure.

Oscillometric method

In this method, a special cuff is used which can sense the arterial waves. By this method continuous Non-invasive BP (NIBP) monitoring is possible. It is mostly used in CCU, HDU & ICUs. Systolic, diastolic & mean arterial pressures (MAP) along with HR are digitally displayed in the monitor. The mean arterial pressure (MAP), recorded by this method is the most accurate.

Home BP monitoring

In last 25 yrs, due to technological improvement of devices for accurate BP measurement, many convenient, inexpensive & relatively accurate instruments are available besides traditional BP measurement instruments. These instruments are mostly semi-automatic (oscillometric) and even persons with hearing difficulties, problems with hand-eye co-ordination can use them easily to measure BP at home. These instruments should be calibrated against a standard mercury sphygmomanometer by using a Y-tube and the measurement technique should also be checked. Home BP recordings are

typically lower (by an average of about 12/7mmHg) than measurements taken in the traditional medical environment, even in normotensive subjects.[16] Home readings correlate more with the target organ damage (TOD) or the risk of mortality than the readings taken in physician's office.[17] One long term study showed that people with much normal or lower home BP recordings (compared with those in physician's office) suffer fewer major CV events than those, who have elevated recordings both at home and in physician's office.[18]

Ambulatory BP monitoring (ABPM)

An individual's BP varies widely throughout a 24hr period and is therefore impossible to characterize accurately except by repeated measurements under various conditions. BP has a reproducible circadian profile with higher values- while awake, when mentally & physically active and during early morning for ≥3hrs during the transition of sleep to wakefulness.[19] Out of office readings are the only way to obtain a clear picture of a persons usual BP for accurate diagnosis & management. Ambulatory monitoring provides automated measurements of BP over a 24hr period while patients are engaging in there usual activities, including sleep. ABPM is done by oscillometric technique or arterial tonometry either at home or physicians office. Recommended normal values include an average daytime BP below 135/85 mmHg, night time BP below 120/70 mmHg and 24hr BP below 130/80 mmHg.[20]

Conclusion

BP measurement is the mostly done clinical examination by the doctors of all disciplines and also by nurses, paramedics, health assistants or even quacks. Now-a-days, people have become more conscious and concerned regarding BP & hypertension. It is our responsibility to measure BP accurately & scientifically and take decision about diagnosis & further management. We should have proper knowledge regarding diagnosis of hypertension. If a patient is diagnosed as hypertensive, he may have to take antihypertensive drugs life long. Again inappropriate control of BP in hypertensive patients will also increase morbidity & mortality by CV events, target organ damage etc and ultimately increase burden to the society. So, accurate BP measurement is now people's demand.

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